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Graham, Hilary Mavis orcid.org/0000-0001-7949-6819, Jarvis, Stuart William orcid.org/0000-0001-8447-0306, Hanley, Nicolas et al. (2 more authors) (2019) Willingness to pay for policies to reduce future deaths from climate change: evidence from a British survey. *Public Health*. pp. 110-117. ISSN 0033-3506

<https://doi.org/10.1016/j.puhe.2019.06.001>

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Original Research

Willingness to pay for policies to reduce future deaths from climate change: evidence from a British survey

H. Graham ^{a,*}, S. de Bell ^b, N. Hanley ^c, S. Jarvis ^a, P.C.L. White ^d^a Department of Health Sciences, University of York, York, YO10 5DD, UK^b European Centre for Environment and Human Health, University of Exeter Medical School, Knowledge Spa, Royal Cornwall Hospital, Truro, Cornwall, TR1 3HD, UK^c Institute of Biodiversity, Animal Health and Comparative Medicine, College of Medical, Veterinary & Life Sciences, Graham Kerr Building, University of Glasgow, Glasgow, G12 8QQ, UK^d Environment and Geography Department, University of York, Wentworth Way, York YO10 5NG, UK

ARTICLE INFO

Article history:

Received 1 February 2019

Received in revised form

28 May 2019

Accepted 3 June 2019

Keywords:

Public health

Future generations

Public perceptions of climate change

ABSTRACT

Objectives: Without urgent action, climate change will put the health of future populations at risk. Policies to reduce these risks require support from today's populations; however, there are few studies assessing public support for such policies. Willingness to pay (WtP), a measure of the maximum a person is prepared to pay for a defined benefit, is widely used to assess public support for policies. We used WtP to investigate whether there is public support to reduce future health risks from climate change and if individual and contextual factors affect WtP, including perceptions of the seriousness of the impacts of climate change.

Study design: A cross-sectional British survey.

Methods: Questions about people's WtP for policies to reduce future climate change-related deaths and their perceptions of the seriousness of climate change impacts were included in a British survey of adults aged 16 years and over ($n=1859$). We used contingent valuation, a survey-based method for eliciting WtP for outcomes like health which do not have a direct market value.

Results: The majority (61%) were willing to pay to reduce future increases in climate change-related deaths in Britain. Those regarding climate change impacts as not at all serious were less willing to pay than those regarding the impacts as extremely serious (OR 0.04, 95% CI 0.02–0.09). Income was also related to WtP; the highest-income group were twice as likely to be willing to pay as the lowest-income group (OR 2.14, 95% CI 1.40–3.29).

Conclusions: There was public support for policies to address future health impacts of climate change; the level of support varied with people's perceptions of the seriousness of these impacts and their financial circumstances. Our study adds to evidence that health, including the health of future populations, is an outcome that people value and suggests that framing climate change around such values may help to accelerate action.

* Corresponding author.

E-mail address: hilary.graham@york.ac.uk (H. Graham).<https://doi.org/10.1016/j.puhe.2019.06.001>0033-3506/© 2019 The Authors. Published by Elsevier Ltd on behalf of The Royal Society for Public Health. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Introduction

The health impacts of climate change on today's populations are becoming increasingly evident.^{1,2} Failure to keep global mean temperatures within 1.5° centigrade of pre-industrial levels will threaten the health of future populations;^{3,4} projections point to increases in global temperatures by 2050 that are significantly above this threshold.^{5,6} In the UK context, increasing temperatures are associated with an increased frequency and intensity of extreme hot weather and flooding; these climate change-related exposures have been highlighted as major risks to the future health of the UK population,^{7–10} with older people and children particularly at risk.^{7,11,12} The Climate Change Act (2008) sets the framework for climate governance in the UK and mandates action on mitigation and adaptation.^{13,14} Both offer significant cobenefits for public health^{1,15,16} and are urgently needed to protect the health of future populations.^{5,6} The health of future populations turns on the actions of today's population and, in particular, on the speed and magnitude of the policy response to climate change.^{1,6,17–19} However, policies—and the economic evaluations that inform them—give greater weight to the well-being of current populations.^{20–22} A time weight (a discount rate) is applied when assessing the costs and benefits of policies, with future costs and benefits valued less highly than current ones. Discounting is designed to take account of the variable timescales over which costs and benefits are distributed.²³ It is also seen to be in line with public's preference to receive benefits now and 'to defer costs to future generations'.²⁰

It is increasingly recognised that standard discounting approaches are less appropriate for policies with long-term effects, including those with impacts on the climate system.²² However, little is known about public preferences for reducing climate change risks for those living in the future. One measure used to assess people's preferences is their willingness to pay (WtP) to help meet the cost of such policies. WtP captures the value that an individual places on an outcome (for example, reduced health risks from climate change) in monetary terms and reflects both the strength of their preference for the outcome and their ability and willingness to give up consumption of other goods to pay for it. We searched Web of Science up to December 2018 for WtP studies framed around the health risks of climate change (using the terms 'health', 'climate change' and 'WtP'). We found very few studies and no UK studies. For example, studies investigated people's WtP to reduce climate change-related health risks from flooding in Switzerland,²⁴ from variations in temperature in Taiwan²⁵ and from air pollution in Pennsylvania;²⁶ they indicated that communicating both the public health and the climate change benefits

of interventions increased people's WtP. Using a representative British survey, we estimate people's WtP for policies to reduce future deaths in the UK that may result from climate change.

Methods

Stated preference (SP) methods provide a survey-based method for estimating the economic value that people attach to outcomes for which there is not a direct market value,^{27–29} such as protecting the health of future populations and improving the natural environment. One widely used SP method is contingent valuation (CV). This asks people how much they would be willing to pay for a benefit in a hypothetical scenario, for example, if they would be willing pay a specified monetary cost (e.g. £1 a month for 10 years) to support a policy that yielded a specified benefit in X years' time.²⁸ The use of SP methods in such contexts is supported by official guidance on how to conduct appraisals of public policy initiatives such as climate change policy.²⁰ For our study, we used deaths, the most widely used health measure and one suitable for a general population survey.³⁰ We derived our measure from the UK's national assessment of future UK deaths from increasing global temperatures.⁷ This estimated an additional 7000 climate change-related deaths per year from heatwaves by the 2050s, with additional, but uncertain, deaths from other climate change-related exposures, including from flooding, worsening air quality and increased pathogens.⁷

Based on a representative British survey, we used CV to estimate people's WtP to reduce future deaths that may result from climate change. The Opinions and Lifestyle Survey (OLS) is a cross-sectional national survey governed by the UK Government's Statistics Authority Office code of practice and overseen by the National Statistician's Data Ethics Advisory Committee.^{31,32} Our study was approved by the Department of Health Sciences Research Governance Committee at the University of York.

The OLS is based on a random probability sample of private households in Britain, drawn from the Postcode Address File (PAF) containing approximately 26m addresses.³² Updated every three months, the PAF is the most complete address database in the UK. The OLS sample is stratified by region and sociodemographic profile. Sociodemographic stratification is based on the proportions of households with no car; households where the household reference person has an occupation in a higher socio-economic group; and people aged >65 years. The survey runs eight months a year; a new sample is drawn each month, and one adult per household is randomly selected for a face-to-face computer-assisted personal

interview. The survey consists of a standard set of socio-demographic questions, together with commissioned modules.

We commissioned a CV question in the January and February 2016 OLS on people's WtP for policies to maintain climate change–related deaths at their current level. Survey participants were asked whether they would be willing to pay ('yes'/'no') an ongoing monthly payment of a randomly assigned 'bid amount' of £1, £2, £5, £10 or £20 to hold climate change–related deaths at current levels rather than see such deaths increase (see Box 1); evidence indicates that binary choices result in a more reliable revelation of preferences.²⁸ The range of bid values was determined from a pilot study, also using the OLS, where participants were asked to choose how much they would pay per month from a choice of £0, £1, £2, £5, £10, £20 or £50.

The question provided additional contextual information on the number of additional annual deaths expected by 2050

Box 1 Willingness-to-pay question.

Each participant was presented with a variation of the following question, in which text in square brackets was varied:

Climate change is expected to have a negative impact on health and well-being, and scientists expect that climate change will cause more deaths in the UK. Scientists from the UK Committee on Climate Change predict that if we continue to use energy in the way we currently do, there may be

- 7000 more deaths per year in the UK by 2050 (over 3 times higher than current levels) and
- 12,000 more deaths per year in the UK by [A] (6 times higher than current levels).

[B] are two groups that are particularly at risk. It will cost money to put in place environmental policies to reduce these risks. We would like to know what you feel would be an acceptable amount of public spending to reduce these impacts.

Would you be willing to pay an additional [X] in your taxes each month for the next ten years to reduce climate-related deaths to current levels?

The varied texts were randomly assigned so that

- A quarter of respondents were presented with A = '2080' & B = 'The elderly and the very young' (of these, one fifth received each of the five bid amounts X: £1, £2, £5, £10, £20)
- A quarter of respondents were presented with A = '2080' & B = 'The elderly' (of these, one-fifth received each of the five bid amounts X: £1, £2, £5, £10, £20)
- Half of respondents were presented with A = '2115' & B = 'The elderly and the very young' (of these, one-fifth received each of the five bid amounts X: £1, £2, £5, £10, £20)

and one of two subsequent years (2080 and 2115) if no additional action was taken; and on the population groups most at risk (the elderly and the very young). This contextual information was provided in one of the three forms (see Box 1), which were randomly assigned to respondents. Participants were also asked, after the question on WtP, 'how would you rate the seriousness of the impacts of climate change?' (hereafter 'perceived seriousness of climate change'). Response options were extremely serious, fairly serious, not very serious or not at all serious.

In line with the OLS average, the response rate across the months of our study was 50% ($n = 1859$). Analyses were performed using Stata, version 15. An estimate of average WtP was obtained from the CV responses by fitting a univariate logistic regression to the binary responses (willing or not willing to pay) with the bid amount as the sole independent variable. To make the results representative of the general population, data were weighted to account of non-response bias and the probability of each respondent being included in the survey.³² Mean and median WtP were calculated from the coefficient associated with the bid amount in the logistic regression model.^{33,34} A sensitivity analysis was also performed, in which all participants with unknown WtP (refused to answer or stated that they did not know) were assumed to be unwilling to pay.

A multivariate logistic regression was then used to assess the association of WtP with other factors. Candidate independent variables were the bid amount; the respondent's perception of the seriousness of climate change; their generation of birth (before 1946; 1946–1965; 1966–1985; after 1985); their individual gross income (split into five bands with approximately equal numbers of participants in each: less than <£7280, £7280–£12,479, £12,480–£18,719, £18,720–£28,599 and ≥£28,600); education (degree level or above, below degree level, none); health status (presence or absence of long-standing limiting illness); gender; parenthood status (presence or absence of a child younger than 16 years in the household); and the context offered in the question. Variables were added in turn and retained if they reduced the Bayesian information criterion (BIC) by more than 3. Multiple imputation with ten iterations using chained equations³⁵ with an ordered logistic model was used to handle missing data for income band and perceived seriousness of climate change. In addition to the candidate-independent variables listed previously, car ownership and employment status were also included in the imputation.

Results

The majority of respondents were willing to answer questions on their perceptions of climate change (98%) and their WtP to reduce climate change–related deaths (97%); the remaining responses were refused or answered 'do not know'. Among the other variables, only income had missing data (7%).

Perceived seriousness of climate change

Climate change was considered extremely or fairly serious by 86% of respondents (Table 1). Some variation was seen

Table 1 – Perceived seriousness of the impacts of climate change.

Demographic grouping	Percent of respondents that consider the impacts of climate change:					% considering impacts extremely or fairly serious	% considering impacts not very or not at all serious	Number of participants
	Extremely serious	Fairly serious	Not very serious	Not at all Serious	Do not know/refused			
All	41	45	9	3	2	86	12	1859
Gender								
Male	40	42	11	5	1	82	16	815
Female	41	48	7	2	3	89	8	1044
Generation								
Pre-1946	31	50	12	4	4	80	16	341
1946–1965	43	41	9	5	3	83	14	630
1966–1985	44	45	7	2	2	89	9	613
Post-1985	41	51	5	2	1	92	7	275
Income band								
Under £7280	44	45	6	2	2	90	9	326
£7280–£12,479	37	44	12	3	4	81	15	368
£12,480–£18,719	38	47	9	4	2	84	14	332
£18,720–£28,599	43	47	5	3	2	91	8	330
£28600 and above	45	42	9	2	2	87	11	367
Do not know/refused	29	49	10	7	6	78	16	136
Level of education								
Degree or above	52	39	5	2	1	92	7	464
Below degree	37	47	9	3	3	84	13	1004
None	35	48	10	4	3	83	14	391

between sociodemographic groups. For example, 80% of the pre-1946 generation considered climate change to be extremely or fairly serious, compared to 92% of the post-1985 generation.

WtP to reduce climate change-related deaths

Overall, 61% of people were willing to pay the amount asked to reduce future climate change deaths (Table 2). As the bid value increased, the probability that people were willing to pay this amount declined. A large majority (78%) were willing to pay if asked for £1 a month, compared with 46% of those asked for £20. The mean amount people were willing to pay was £19.17 (95% confidence interval [CI] £15.64 – £22.70, Table 3).

The final multivariate model included the bid amount, perceived seriousness of climate change, birth generation, income band and level of education. Health status, parent-hood status and context offered in the question (timescales for increased deaths and the elderly/very young as high-risk groups) did not improve model fit as measured by the BIC (nor did they have a statistically significant association with WtP) and were excluded. Income was associated with WtP to reduce climate change deaths (Table 4); compared to people in

the lowest income band, people in the highest income band were more than twice as likely to be willing to pay (odds ratio [OR] 2.14, 95% CI 1.40–3.29). Perceptions of climate change were also associated with WtP, with respondents who considered it not at all serious being far less likely to pay than those who thought it was extremely serious (OR 0.04, 95% CI 0.02–0.09).

The findings were robust to sensitivity analyses assuming non-response to the WtP question indicated unwillingness to pay (Table 4) and also to modelled scenarios in which non-response to the income question was assumed to be missing not at random (Appendix). Multiple imputation changed associations significantly only in relation to generation of birth; without multiple imputation, post-1965 generations were more likely to be WtP than the 1946–1965 generation. This may reflect some bias introduced in the non-imputed model by the missing data. The lack of an association between WtP and birth generation may be due to mediation through perceptions of the seriousness of climate change and income, both included in the models. Uncertainty around perceptions of the future impacts of climate change has been identified as needing further investigation in WtP studies.²⁴

Table 2 – Willingness to pay to reduce climate change-related deaths.

Amount asked, £	Percent willing to pay	Percent not willing to pay	Percent do not know/refused	Number of participants
1	78	20	2	344
2	70	27	3	381
5	60	38	2	407
10	51	45	4	368
20	46	51	3	359
All amounts	61	36	3	1859

Amount willing to pay	Main model, data as received with missing responses to WtP question	Sensitivity analysis, all missing assumed to be unwilling to pay
Mean	19·17 (95% CI £15·64 – £22·70)	18·61 (95% CI £15·16 – £22·06)
Median	14·16 (95% CI £11·84 – £16·47)	13·13 (95% CI £10·96 – £15·29)

CI, confidence interval.

The majority of study participants considered climate change to be a serious problem, a finding consistent with evidence that most adults in the UK are worried about climate change.^{36–38} Perceptions of the severity of climate change may be a result of the increase in extreme weather and flooding in the UK, and a consequent heightened sensitivity to the adverse impacts of climate change.³⁹

was not tied specifically to concern about the future welfare of one's children.

WtP was significantly associated with perceptions of climate change. Those who thought climate change to be a more serious problem were more willing to pay for policies to reduce to address it, a finding consistent with other WtP studies.^{18,24} The connection between perceptions of climate change and WtP has been attributed to a sense of responsibility for the environment and future generations as well as a desire to reduce one's own exposure to climate change risks.^{24,26,36}

People were less willing to support policies to address climate change-related risks to health as the cost to them increased. There is evidence that the public support action on climate change at the national and international levels but oppose tax policies that would affect them directly.⁴¹ WtP was lower for those in the lowest income band compared to the highest, a pattern found in most,^{24,25,36} but not all,²⁶ studies. Studies of the relationship between household income and stated WtP typically reveal rather low elasticities (less than unity).⁴² Lower WtP among those on lower incomes may not reflect lower concern, but simply lower ability to pay. Meeting the costs of climate change through progressive systems of

	Main model, data as received with missing responses to WtP question			Sensitivity analysis, all missing assumed to be unwilling to pay		
	Odds ratio	95% CI	P-value	Odds ratio	95% CI	P-value
Bid amount (per £10)	0.47	0.40-0.56	<0.01	0.49	0.41-0.58	<0.01
Perceived seriousness of effects of climate change						
Extremely serious	1			1		
Fairly serious	0.35	0.27-0.46	<0.01	0.36	0.28-0.48	<0.01
Not very serious	0.08	0.05-0.13	<0.01	0.09	0.05-0.14	<0.01
Not at all serious	0.04	0.02-0.09	<0.01	0.05	0.02-0.11	<0.01
Generation						
Pre-1946	1.08	0.76-1.53	0.66	1.09	0.78-1.53	0.61
1946-1965	1			1		
1966-1985	1.32	0.98-1.80	0.07	1.32	0.98-1.78	0.07
Post-1985	1.38	0.93-2.06	0.11	1.38	0.94-2.02	0.10
Income band						
Under £7280	1			1		
£7280-£12,479	1.15	0.78-1.68	0.48	1.20	0.83-1.73	0.33
£12,480-£18,719	1.72	1.14-2.59	0.01	1.65	1.11-2.45	0.01
£18,720-£28,599	1.24	0.83-1.85	0.29	1.37	0.92-2.02	0.12
£28,600 and above	2.14	1.40-3.29	<0.01	2.18	1.44-3.32	<0.01
Level of education						
Degree or above	1.37	1.00-1.88	0.05	1.33	0.98-1.81	0.07
Below degree	1			1		
None	0.80	0.58-1.12	0.20	0.79	0.57-1.08	0.14

CI, confidence interval.

taxation (e.g. income tax) could provide an equitable approach to funding these policies.

Some limitations of the study should be noted. Firstly, people's perceptions of climate change and therefore their WtP to reduce its health impacts may be related to factors beyond the scope of our study, including an individual's experience of extreme weather events³⁹ and concerns about non-health-related impacts of climate change such as damage to property and infrastructure.^{43,44} Context is important in encouraging concern and WtP for policies to address climate change.^{45,46} However, in our study, variations in the contexts presented were not associated with a significant change in WtP. WtP was not affected by whether the very young were said to be at particular risk in addition to the elderly or by the timeframes and severity of the projected impacts. This may reflect a low discount rate among respondents, such that avoided deaths in 2050 were not viewed as significantly more desirable than avoided deaths in 2115. Across such long time periods, intragenerational time preferences (an individual's preference for the timing of benefits across generations) may be a factor.^{18,47} The low discount rate may also reflect a lack of information on how the risk reduction would be achieved in practice. An individual's WtP may be policy sensitive, influenced, for example, by perceptions of and preferences for climate change mitigation and adaptation,⁴⁸ as well as by views on the effectiveness and fairness of such policies.⁴⁹ Including such potential influences on WtP was not possible using our chosen study design (questions inserted into a general survey) but would merit further investigation. We would also seek to explore non-WtP in greater depth. Of those asked to pay £1 per month, one in five were unwilling, a proportion rising to four in five among those who considered the effects of climate change to be not at all serious. Finally, our cross-sectional study predates the recent increased public debate about climate change action; given increasing public concern about climate change,⁵⁰ a follow-up study may find a larger majority of adults willing to pay to reduce its future health impacts.

Secondly, SP methods may elicit responses that are not in line with real choice behaviour. In particular, WtP is estimated from questions based on hypothetical scenarios; study participants may therefore not regard their responses as consequential (as having real-world consequences). Our question on the perceived seriousness of climate change provided an indication of whether the individual believed in and cared about the scenario; these affective attributes have been found to be associated with respondents regarding the scenario as one likely to be implemented.⁵¹ Nonetheless, a study where participants believed they would be required to pay if the proposed policy secured popular support—for example, a study linked to a public consultation on policy options—would be an important next stage in establishing people's WtP to reduce the future health risks of climate change because we know from other work that consequentiality is an important aspect of demand revelation in SP methods.⁵¹

SP methods are the only ones available for estimating economic values for which there is not a market value or other data based on people's behaviour²⁸ (for example, a policy experiment enabling comparisons to be made between exposed and non-exposed populations). We followed

standard SP guidelines for survey design, including the identification of a representative sample of the potentially affected population, a single binary-choice question (yes/no) that included a baseline 'status quo' condition (the current number of deaths), designation of who pays ('you'), payment amounts and frequency, a change mechanism (a policy intervention) and a defined benefit (reduced climate change-related deaths at specific points in time) that, because it was based on official estimates, would be likely to be deemed credible by survey participants. The question was also piloted in an earlier ONS survey to ensure it was understood by the study participants.

Thirdly, our study explored associations between WtP and income, generation and education. All three factors were included in our final model, and model fit supported their inclusion. While it is possible that there are interactions between the factors, sample sizes were insufficient to fully explore this. However, such possible interactions do not impact on the main aim of our study: to assess population-level WtP for a defined future public health benefit.

Our study had a number of further strengths. As well as being based on a representative survey of adults in Britain using individual home-based interviews, it collected a range of sociodemographic data, including educational attainment, income and parental status, enabling analysis of their association with WtP. There were few missing data for most variables used in the models. As missing data in variables used in the multivariate model may bias estimation, mean and median WtP were estimated from the univariate model; using data imputation, mean and median WtP were also estimated from the multivariate model and the 95% CIs of these estimates included the point estimates from the univariate model provided in Table 3. The sensitivity analyses, which treated all missing data on WtP as refusal to pay, set a lower bound on the WtP estimates that were not significantly different to those from the main model.

Across a range of scenarios, respondents expressed a WtP to reduce future health impacts of climate change, suggesting that health, including the health of future populations, is an outcome that people value.^{1,18,24,40} Such a health framing is supported by evidence of the adverse health impacts of climate change and the opportunities for health co-benefits of mitigation and adaptation, particularly for future populations.^{1,15,16} However, although the Paris Agreement to strengthen the global response to climate change recognised the right to health,⁵² health remains marginal to climate change policies and public debate.^{1,53} In this context, public support for climate change policies that yield health benefits underlines the important role to be played by the public health community in accelerating national and global action on climate change.^{1,54}

Author statements

Acknowledgements

The Office of National Statistics (ONS) collected the data for the study; the study authors undertook the analyses and interpretation. The authors would like to thank participants in

the ONS Opinions and Lifestyle Survey for their help with the study.

Ethical approval

The Opinions and Lifestyle Survey (OLS) is a cross-sectional national survey governed by the UK government's Statistics Authority Office code of practice and overseen by the National Statistician's Data Ethics Advisory Committee.

Funding

This work was supported by the UK's Economic and Social Research Council (ESRC), grant number ES/L003015/1.

Competing interests

None declared.

REFERENCES

- Watts N, Amann M, Ayeb-Karlsson S, Belesova K, Bouley T, Boykoff M, et al. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet* 2018;391:581–630.
- Thomas F, Sabel CE, Morton K, Hiscock R, Depledge MH. Extended impacts of climate change on health and wellbeing. *Environ Sci Policy* 2014;44:271–8.
- Intergovernmental Panel on Climate Change (IPCC). Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. 2018. Available from: <https://www.ipcc.ch/sr15/>.
- Schafer PL, Farrell JB. Turn up the heat. *Water Environ Technol* 2000;12:26–34.
- Hansen J, Kharecha P, Sato M, Masson-Delmotte V, Ackerman F, Beerling DJ, et al. Assessing “dangerous climate change”: required reduction of carbon emissions to protect young people, future generations and nature. *PLoS One* 2013;8:e81648.
- Hansen J, Sato M, Kharecha P, Von Schuckmann K, Beerling DJ, Cao J, et al. Young people's burden: requirement of negative CO₂ emissions. *Earth Syst Dyn* 2017;8:577–616.
- Committee on Climate Change. *Managing climate risks to well-being and the economy. Adaptation Sub-Committee Progress Report* 2014. London: Committee on Climate Change; 2014.
- Committee on Climate Change. *UK climate change risk assessment* 2017. 2017. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/584281/uk-climate-change-risk-assess-2017.pdf.
- Environment Agency. *Climate change impacts and adaptation*. 2018. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/758983/Climate_change_impacts_and_adaptation.pdf.
- Department of Health. *Health effects of climate change in the UK*. 2012. Available from: https://www.climateinthenorthireland.org.uk/cms/files/resources/files/Health-Effects-of-Climate-Change-in-the-UK_Department-of-Health.pdf.
- Macintyre H, Heaviside C, Taylor J, Picetti R, Symonds P, Cai X-M, et al. Assessing urban population vulnerability and environmental risks across an urban area during heatwaves—Implications for health protection. *Sci Total Environ* 2018;610:678–90.
- Mort M, Walker M, Williams AL, Bingley A. Displacement: critical insights from flood-affected children. *Health Place* 2018;52:148–54.
- Committee on Climate Change. *Net Zero: the UK's contribution to stopping global warming*. 2019. Available from: <https://www.theccc.org.uk/wp-content/uploads/2019/05/Net-Zero-The-UKs-contribution-to-stopping-global-warming.pdf>.
- Department for Environment and Rural Affairs. *The national adaptation programme and the third strategy for climate adaptation reporting: making the country resilient to a changing climate*. 2018. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/727252/national-adaptation-programme-2018.pdf.
- Haines A. Health co-benefits of climate action. *The Lancet Planet Health* 2017;1:e4–5.
- Markandya A, Sampietro J, Smith SJ, Van Dingenen R, Pizarro-Irizar C, Arto I, et al. Health co-benefits from air pollution and mitigation costs of the Paris Agreement: a modelling study. *The Lancet Planet Health* 2018;2:e126–33.
- World Bank. *Climate change action plan*. Washington, US: World Bank; 2016.
- Graham H, Bland JM, Cookson R, Kanaan M, White PC. Do people favour policies that protect future generations? Evidence from a British survey of adults. *J Soc Policy* 2017;46:423–45.
- Forzieri G, Cescatti A, e Silva FB, Feyen L. Increasing risk over time of weather-related hazards to the European population: a data-driven prognostic study. *The Lancet Planet Health* 2017;1:e200–8.
- Treasury HM. *The Green Book: central government guidance on appraisal and evaluation*. London: HM Treasury; 2018. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/685903/The_Green_Book.pdf.
- Frederick S, Loewenstein G, O'Donoghue T. Time discounting and time preference: a critical review. *J Econ Lit* 2002;351–401.
- Stern N, Peters S, Bakhshien V, Bowen A, Cameron C, Catovsky S, et al. *Stern review: the economics of climate change*. Cambridge: Cambridge University Press; 2007.
- Oliver A. A normative perspective on discounting health outcomes. *J Health Serv Res Policy* 2013;18(3):186–9.
- Veronesi M, Chawla F, Maurer M, Lienert J. Climate change and the willingness to pay to reduce ecological and health risks from wastewater flooding in urban centers and the environment. *Ecol Econ* 2014;98:1–10.
- Liao S-Y, Tseng W-C, Chen P-Y, Chen C-C, Wu W-M. Estimating the economic impact of climate change on cardiovascular diseases—evidence from Taiwan. *Int J Environ Res Public Health* 2010;7:4250–66.
- Sergi B, Davis A, Azevedo I. The effect of providing climate and health information on support for alternative electricity portfolios. *Environ Res Lett* 2018;13:024026.
- Atkinson G, Groom B, Hanley N, Mourato S. Environmental valuation and benefit-cost analysis in UK policy. *J Benefit-Cost Anal* 2018;9:97–119.
- Johnston RJ, Boyle KJ, Adamowicz W, Bennett J, Brouwer R, Cameron TA, et al. Contemporary guidance for stated preference studies. *J Assoc Environ Res Econ* 2017;4:319–405.
- Carson RT. Contingent valuation: a practical alternative when prices aren't available. *J Econ Perspect* 2012;26:27–42.
- Thacker SB, Stroup DF, Carande-Kulis V, Marks JS, Roy K, Gerberding JL. Measuring the public's health. *Publ Health Rep* 2006;121:14–22.
- UK Statistics Authority. *Code of practice for official Statistics*. London: UK Statistics Authority; 2009 January 2009.

32. Office for National Statistics (ONS). *Opinions and Lifestyle survey information guide*. London: Office for National Statistics; 2014.
33. Hanemann WM. Welfare evaluations in contingent valuation experiments with discrete responses. *Am J Agric Econ* 1984;**66**:332–41.
34. Hanemann WM. Welfare evaluations in contingent valuation experiments with discrete response data: reply. *Am J Agric Econ* 1989;**71**:1057–61.
35. Raghunathan TE, Lepkowski JM, Van Hoewyk J, Solenberger P. A multivariate technique for multiply imputing missing values using a sequence of regression models. *Surv Methodol* 2001;**27**:85–96.
36. Brouwer R, Brander L, Van Beukering P. “A convenient truth”: air travel passengers’ willingness to pay to offset their CO₂ emissions. *Clim Change* 2008;**90**:299–313.
37. Steentjes K, Pidgeon NF, Poortinga W, Corner AJ, Arnold A, Böhm G, et al. *European perceptions of climate change (EPCC): topline findings of a survey conducted in four european countries in 2016*. Cardiff: University of Cardiff; 2017.
38. Phillips D, Curtice J, Phillips M, Perry J, editors. *British social attitudes: the 35th report*. London: The National Centre for Social Research; 2018.
39. Demski C, Capstick S, Pidgeon N, Sposato RG, Spence A. Experience of extreme weather affects climate change mitigation and adaptation responses. *Clim Change* 2017;**140**:149–64.
40. Asensio OI, Delmas MA. Nonprice incentives and energy conservation. *Proc Natl Acad Sci Unit States Am* 2015;**112**:E510–5.
41. Leiserowitz A. Climate change risk perception and policy preferences: the role of affect, imagery, and values. *Clim Change* 2006;**77**:45–72.
42. Barbier EB, Czajkowski M, Hanley N. Is the income elasticity of the willingness to pay for pollution control constant? *Environ Resour Econ* 2017;**68**:663–82.
43. Lee JJ, Cameron TA. Popular support for climate change mitigation: evidence from a general population mail survey. *Environ Resour Econ* 2008;**41**:223–48.
44. Botzen WW, van den Bergh JC. Risk attitudes to low-probability climate change risks: WTP for flood insurance. *J Econ Behav Organ* 2012;**82**:151–66.
45. Lorenzoni I, Pidgeon NF. Public views on climate change: European and USA perspectives. *Clim Change* 2006;**77**:73–95.
46. Lorenzoni I, Nicholson-Cole S, Whitmarsh L. Barriers perceived to engaging with climate change among the UK public and their policy implications. *Glob Environ Chang* 2007;**17**:445–59.
47. Chapman GB. Time preferences for the very long term. *Acta Psychol* 2001;**108**:95–116.
48. Taylor AL, Dessai S, de Bruin WB. Public perception of climate risk and adaptation in the UK: a review of the literature. *Climate Risk Management* 2014;**4**:1–16.
49. Ščasný M, Zvěřinová I, Czajkowski M, Kyselá E, Zagórska K. Public acceptability of climate change mitigation policies: a discrete choice experiment. *Clim Policy* 2017;**17**:S111–30.
50. Department for Business Energy and Industrial Strategy. BEIS public attitudes tracker. March 2019 (wave 29). 2019. Available from: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/800429/BEIS_Public_Attitudes_Tracker_-_Wave_29_-_key_findings.pdf.
51. Needham K, Hanley N. Prior knowledge, familiarity and stated policy consequentiality in contingent valuation. *J Environ Econ Policy* 2019. <https://doi.org/10.1080/21606544.2019.1611481>.
52. United Nations (UN). *Paris agreement*. 2015. Available from: https://unfccc.int/sites/default/files/english_paris_agreement.pdf.
53. Schütte S, Depoux A, Vigil S, Kowalski C, Gemenne F, Flahault A. *The influence of health concerns in scientific and policy debates on climate change*. BMJ Publishing Group Ltd; 2017. Report No.: 0143-005X.
54. Frumkin H, Hess J, Luber G, Malilay J, McGeehin M. Climate change: the public health response. *Am J Public Health* 2008;**98**:435–45.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.puhe.2019.06.001>.